

ON HYALITE.

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The investigation of hyalite, some of the results of which are recorded in the following note, first suggested itself to the authors whilst they were engaged in studying the optical behaviour of liquid spherulites.

An attempt was being made to find a solid spherulitic body analogous—both as regards internal structure and optical behaviour—with the type of liquid spherulite described by Lehmann, in which the molecules of the substance are regarded by him as being arranged either along lines radiating outwards from the centre of the spherulite, or on the surfaces of spheres possessing a common centre—the centre of the spherulite.

As a result of a preliminary examination of a number of substances selected for this purpose, hyalite was chosen as being the most promising.

In this way one was led to consider the nature of what is commonly termed the “anomalous double refraction” of hyalite. In this connection Dana * writes as follows :

“(Opal) often shows double refraction similar to that observed in colloidal substances due to tension. The mammillary form *Hyalite* often yields the uniaxial interference cross of a negative substance in parallel polarised light; † this is referred to tension by Schultze, Ber. nied. Ges., 69, 1861.”

Similarly Rosenbusch ‡ :

“Hyalite is doubly refracting, and, under certain conditions, exhibits the interference cross of a uniaxial substance with isochromatic curves. This appearance is referred to conditions of strain occasioned by the concentric shell-like structure of the mineral. The character of the double refraction is negative. The hyalite cross often separates into hyperbolas during a rotation of the section between crossed nicols, which would necessarily be the case if the layers were not regular spherical shells.”

* Dana, A System of Mineralogy, 6th ed., p. 194.

† The italics are ours.

‡ Rosenbusch (Iddings), Microscopical Physiography of Rock-making Minerals, 4th ed., p. 194.

The material investigated was supplied to the Geological Department of the University of Cape Town by Foote of Philadelphia, and is labelled as having been obtained from Guanajuato, Mexico.

The specimen represents a portion of a succession of deposits which presumably originally lined a rock cavity. Several "forms" of silica—some chalcedonic, others opaline—are represented, and, in our opinion, judging from this single specimen, a definite order of deposition is observable.

We infer that, throughout a period of continuous deposition, the chalcedonic varieties were deposited at the commencement, and the opaline varieties towards the close, of such a period.

These varieties, enumerated in the order in which we consider them to have been deposited, are as follows :—

Chalcedonic Silica.

1. Dark chocolate-brown variety resembling jasper.
2. Opaque, white ; in parts bluish-white.
3. Pale blue or bluish-white, semi-translucent ; botryoidal (pale brown by transmitted light).

Opaline Silica.

4. Clear, colourless, botryoidal hyalite.
5. Extremely pale bluish-white, opalescent or slightly clouded hyalite ; spheroidal in form, and much less common than the colourless and water-clear hyalite. (Since this variety generally occurs forming semi-spheroid masses on the surface of the clear hyalite, no difficulty is experienced in distinguishing between the two—particularly when both are immersed in water,—but, when the slightly clouded variety is detached from the clear, optical examination proves the surest method for its identification. It is important to note also that, in certain parts of the specimen, the small semi-spheroids of this variety are coated with a thin layer of clear hyalite.)

Apparently the forms of silica enumerated above were not the result of one continuous period of deposition, but of several such periods ; nor was deposition uniform over the whole surface of the cavity throughout each period. Several repetitions of the sequence 2, 3, 4, 5 are observable.

In the following we refer principally to two kinds of thin sections, which, for convenience, we propose to name "diametral" and "tangential" respectively. By "diametral section" we mean one cut approximately through the centre of a spherulite ; by "tangential section" one prepared from the surface layer of such a body.

Throughout the preparation of any one section the material was closely observed in order to see whether the grinding—the process by which all

the sections were made—had caused to appear within the material any structures which might be attributable to a release from internal strains consequent on the destruction of the spheroid. Nothing of this nature was observed. Occasionally a section would break along irregular cracks, but, generally speaking, they retained their circular outline unbroken and did not show, when examined under the microscope in ordinary transmitted light, any signs of a strained internal concentric structure.

THE COLOURLESS AND WATER-CLEAR HYALITE.

Diametral Sections.

(a) Examination in plane polarised light.

A diametral section of this variety, when placed on the stage of the microscope so that the axis of the microscope passes through the centre of the spheroid, exhibits, when examined in plane polarised light between crossed nicols, a figure consisting of a black cross with isochromatic rings resembling that given by a uniaxial mineral in convergent polarised light. On the insertion of a quarter undulation mica plate the figure behaves in a similar manner to that of a negative uniaxial substance; many sections were tested in this way, and in all cases the sign was negative. A movement of the section, however, causes a movement of the figure, so that whenever the section is excentrically placed the figure resembles and behaves like a partial uniaxial figure. On this account we do not regard this figure given by hyalite as being analogous with that of a uniaxial mineral in convergent polarised light; sections of radiating chalcedony (described by Miers as a biaxial mineral) and diametral sections of oolitic grains have been observed to give, under similar conditions, figures resembling, both in general appearance and optical behaviour, those given by hyalite.

(b) Examination in convergent polarised light.

The behaviour of diametral sections in convergent polarised light is essentially similar to their behaviour in plane polarised light.

Tangential Sections.

(a) Examination in plane polarised light.

Tangential sections, between crossed nicols, are either quite isotropic or show very slight graying marginally.

(b) Examination in convergent polarised light.

In convergent light a tangential section yields a figure composed solely of a black cross; owing to the thinness of the section and the weak strength

of birefringence of the mineral, no colours are produced. The cross remains stationary within a comparatively wide range of motion of the section; on the rotation of the latter it breaks up into two hyperbolæ—but this separation, although apparent, is so slight that we hesitate to proclaim the biaxial nature of the figure. We do, however, regard it as being a true axial figure.

The sign of the mineral, determined from these figures by means of a quarter undulation mica plate, is negative.

THE OPALESCENT OR SLIGHTLY CLOUDED HYALITE.

Thin sections of this variety have a very faint brownish tint when viewed by transmitted light. The important difference between this and the clear hyalite, so far as optical behaviour is concerned, is in the sign of the double refraction; whereas the nature of the double refraction of the clear is negative, that of the slightly clouded is positive. In other respects, what has been written concerning the clear applies also to this variety.

COMPOUND SPHEROIDS.

Mention has been made of the occurrence of spheroids of the slightly clouded hyalite having an external layer of colourless hyalite. A section intermediate between a tangential and a diametral section was prepared from one of these. When this section was examined in plane polarised light it exhibited an extinction figure composed of a black cross and a black ring—the latter being comparatively close to the margin of the section. On testing this figure with a quarter undulation mica plate it became apparent that the black ring was of the nature of a compensation band resulting from the overlapping of the two varieties—positive and negative—consequent on the curvature of the spheroid.

Subsequently a section was made through a cluster of such spheroids, which, on examination, revealed the fact that in some spheroids there is a repetition of concentric layers of positive and negative material.

FURTHER EXPERIMENTS AND OBSERVATIONS.

(a) *Examination by means of X-rays.*

X-rays were passed through a thick diametral section of the clear hyalite, and the effect of the mineral on the rays was ascertained by means of a photographic plate—after the method of von Laue. The “pattern” showed that, for a given radius, the dispersion had been uniform around the central spot.

(b) *The effects of heat.*

It was observed that, when a fragment of clear hyalite was heated on platinum foil in a bunsen flame, thin flakes split off from its surface, and that these flakes eventually curled and became portions of spherical surfaces; in addition they lost their glassy appearance and turned opalescent.

A somewhat thick diametral section, placed on a glass slip and heated as above, became opalescent and curled into a concavo-convex shape, whilst at the same time a small spherical kernel split out from its centre. When the concavo-convex portion was examined under the microscope, it was found to have a pale-brown colour by transmitted light; further, between crossed nicols in plane polarised light it yielded an extinction figure having a positive sign—that is, having the same sign as the naturally occurring opalescent hyalite previously described.

Portions of some of the flatter opalescent shells obtained by heating behaved in a very similar manner to tangential sections of the naturally occurring form.

(c) *Chemical examination.*

Material was submitted to Mr P. R. v. d. Riet Copeman for analysis, with a view to finding out what chemical change had accompanied the change in sign produced by heating. From a series of silica determinations, and assuming the general formula of hyalite to be $\text{SiO}_2 \cdot n\text{H}_2\text{O}$, he arrived at the following conclusions:—

1. The loss—presumably water—on heating the clear hyalite at bunsen heat was 2.98 per cent.

2. The clear contains 10.28 per cent. water.

3. The naturally occurring opalescent hyalite contains 7.55 per cent. water.

From the above it appears that the artificially produced opalescent hyalite has almost the same water content as the naturally occurring opalescent form.

REMARKS IN CONCLUSION.

Our chief object in writing this note has been to record observations pending the arrival of more material for further investigation. At present we feel we can only write tentatively regarding the reasons why hyalite is doubly refracting. We consider that the explanation that it is due to tension is, at the best, an insufficient one; we are inclined to regard the occurrence of spheroids composed of concentric layers of positive and negative material as making this view—considering it as being the sole explanation—untenable.

We would suggest that hyalite is a substance of which the component

molecules are anisotropic unities ; that their arrangement in the naturally occurring forms may be due to strains, but that their crystallographic orientation, on which the sign of the double refraction depends, is due to their water content.

One of us * has shown in a previous paper how, by gradually driving off the water which it contains, the internal molecular structure of brucite is changed ; this change is tantamount to an alteration of the axial ratio of the mineral. Keeping this in mind, and taking into consideration also the fact that whenever the clear negative hyalite is heated to redness it becomes converted into an opalescent positive material resembling the naturally occurring opalescent hyalite, we cannot help but feel that the water content is the most important factor in deciding the nature of the double refraction of hyalite.

That tangential sections of hyalite behave as uniaxial—or biaxial ?—mineral substances we regard as evidence in support of our contention that the molecules are in themselves anisotropic.

In conclusion, we wish to thank the Royal Society of South Africa for the grant in aid of research.

* J. S. v. d. Linden, *Trans. R. Soc. S. Afric.*, Vol. VII, Pt. 1, 1918, p. 59.